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NOISE AND SPEECH LEVELS ASSOCIATED WITH THE F-111A PREP AREA, McCLELLAN AFB

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13. ABSTRACT

The purpose of this study was (1) to measure the ambient noise environment and speech reception levels associated with the F-111A flight prep area at McClellan AFB, California, (2) to measure noise attenuation characteristics of several ear protection devices contemplated for use in the ambient noise and (3) to determine maximum permissible human exposure durations based on these data. The results show that a H-133 (standard AF communication headset, microphone) in combination with a custom molded insert communication earplug would permit personnel to be exposed up to 8 hours continuously at the 70% and 85% engine power settings. These time limits decrease to 36 minutes per 8 hour day during afterburner zone 5. Even in the highest noise levels, communication capability was satisfactory with this earplug/headset combination.

Details of illustrations in
this document may be better
studied on microfiche

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FOREWORD

This study was accomplished by the Biodynamics and Bionics Division of the Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio, in response to a request of the 2793D USAF Dispensary, McClellan AFB, California. The research was conducted by Mr. Henry C. Sommer and Lt Col Justus F. Rose, Jr., under Project 7231, "Biomechanics of Air Force Operations: Effects of Mechanical Forces on Air Force Personnel," Task 723103, "Effects of Operational Noise on Air Force Personnel," and Task 723104, "Measurement of Noise and Vibration Environments of Air Force Operations." Acknowledgement is made of Mr. Zane Martin of the 2793D USAF Dispensary, McClellan Air Force Base, California for his assistance in arranging the data acquisition phase of this study. The work covered herein was accomplished during the period May to November 1970.

This technical report has been reviewed and is approved.

H. E. G. VON GIERKE, Dr Ing
Director
Biodynamics and Bionics Division

SECTION I

INTRODUCTION

The high levels of noise encountered during ground runup of F-111 aircraft in the flight prep shelter area at McClellan AFB, California cannot be reduced by changes in the physical arrangement. These excessive noise levels pose a serious hearing damage and speech reception problem to ground maintenance personnel using standard H-133 headset, microphone communication units. To reduce or eliminate these problems, ground maintenance personnel were provided custom molded ear insert communication devices to be worn in conjunction with the standard H-133 communication units. This combination was judged by the wearing personnel to be very satisfactory even in the higher levels of noise. Although the subjective ratings of these units were high, objective measures were required to adequately define potential auditory risk problems.

The purpose of this study is to describe the acoustic noise environment associated with F-111 prep area (Section II) and the speech sound pressure levels received at the ear using the F-111 aircraft intercom (Section III). Also, to describe real-ear attenuation characteristics of several devices contemplated for use in the noise environ (Section IV), and present maximum permissible human exposure times (Section V).

SECTION II

AMBIENT SOUND PRESSURE LEVELS

NOISE MEASUREMENTS

Sound pressure level measurements were made on F-111A, No. 082 at McClellan Air Force Base, California in the prep hangar during the engine trimming operation on 12 August 1970. Aircraft 082 is a production F-111A equipped with two Pratt and Whitney TF30-P-3 turbofan engines. Measurements were made at five different locations where ground personnel are typically positioned during engine trimming ground runups (figure 1) for five different engine power settings: (1) Right Engine - 70%, Left Engine - Idle, (2) Right Engine - 85%, Left Engine - Idle, (3) Right Engine - Military, Left Engine - Idle, (4) Right Engine - Zone 3 Afterburner, Left Engine - Idle, (5) Right Engine - Zone 5 Afterburner, Left Engine - Idle. The noise survey microphone was hand held at a height of 5 to 6 feet (approximate level of the ear) above the floor.

The front of the hangar was open and the corrugated metal siding had been removed from the rear wall leaving only the structural members. A blast deflector was positioned approximately 20 feet from the engine exhaust behind the runup hangar.

INSTRUMENTATION AND DATA REDUCTION

A portable, high quality instrumentation package (PORTAPAK) developed in this laboratory was used to acquire the noise data. This system employs condenser microphones for acoustic transducers, signal conditioning equipment to provide maximum signal to noise and dynamic range, and a battery-operated portable magnetic tape recorder. Specifications for this system in brief are as follows: an essentially flat frequency response from 20 Hz to 20 KHz,

dynamic range with 1-inch condenser microphone 40 to 135 dB, dynamic range with 1/2-inch condenser microphone 51 to 148 dB and gain control -15 to +30 dB. A battery-operated pistonphone was used as a reference sound pressure level in field calibration. Spectral analysis of the recorded data were accomplished in the laboratory using a one-third octave band real time analyzer with true RMS detection. For all analyses in this study, an 8-second integration time was used which means that the true RMS was computed for an 8 second period of each data sample. The entire system was calibrated and small corrections applied to the data to compensate for system response, including the change in sensitivity of microphones as a function of sound wave incidence. All measured data reported herein were 10 dB or more above the noise floor of the measurement system. Calculations of A-weighted and C-weighted overall sound levels and permissible exposure times with and without ear protection were accomplished digitally. Octave band SPL were also calculated for each location/condition from the one-third octave band data.

RESULTS

Table I and II present 1/3-octave band analyses for each of the five positions as listed on figure 1 for the various thrust settings. Figures 2, 3, 4, 5 and 6 present the maximum and minimum 1/3-octave SPL, for all positions, at engine power settings of 70%, 85%, military, zone 3 afterburner, and zone 5 afterburner, respectively.

At the 70% power setting a sharp peak occurs at 2 kHz, with a shift of this peak to 3.15 kHz as the engine power increases to 85%. At military, zone 3 and zone 5 afterburner this "pure tone" component diminishes as the adjacent bands increase in SPL.

Table III and IV present the measured data in full-octave bands. As in the 1/3-octave band analysis, for all positions the SPL increases as the engine power increases.

SECTION III

SPEECH ANALYSIS

SPEECH MEASUREMENT

The communication system used at the McClellan AFB F-111A flight prep area was built into the F-111A (AIC-18). All stations used "hot mike" conditions. Continuous operational and controlled phrase speech recordings were made using the same instrumentation as described in the ambient noise measures section. Since a Telex "button" receiver was used as the transducer with the communication system being evaluated, a Bruel and Kjaer (B & K) 2 cc coupler was attached to a B & K pressure microphone for data recordings. The speech recordings were obtained with the AIC amplifier gain set to maximum. A line potentiometer, inserted into the line for operator control, was varied to obtain speech recordings at the maximum and minimum gain settings.

Additional investigations were conducted in the laboratory to determine speech spectrum and intensity for the standard Air Force H-133 communication headset. These investigations used similar instrumentation and appropriate microphone couplers.

RESULTS

Figure 7 shows the third-octave band sound pressure levels generated by the Telex receiver during an operational type talking situation. These data were obtained with the ground power cart in operation (approximately 100 ft away from the talker) and the F-111A engines not operating. The lower curve shows the sound pressure levels generated when talking at a normal conversational level with the line potentiometer set for minimum gain. The middle curve shows the sound pressure levels for normal talking with the line potentiometer set for maximum gain. The difference (between maximum and

minimum gain) reflects an overall dB change of approximately 22 dB. In otherwords, the line potentiometer provides an overall attenuation capability of approximately 22 dB.

The upper curve of figure 7 shows the sound pressure levels generated during loud talking. This curve represents a close approximation of the maximum speech sound pressure levels generated at the Telex receiver during F-111 engine runup with the line potentiometer set for maximum gain.

Figure 8 shows the effect of maximum and minimum line potentiometer gain settings for a standard speech phrase read in a relatively quiet ambient noise condition. The difference in overall sound pressure level again reflects that the line potentiometer attenuation is approximately 22 dB. Both the operational and control type conversation had similar overall sound pressure levels for both maximum and minimum gain settings, 116 dB versus 115 dB at maximum gain and 94 dB versus 91 dB for minimum (dB re 0.00002 N/m^2).

As seen in figure 9 the frequency response of the Telex receiver shows a peak at 1.5 kHz. This peak is also represented in the speech spectra of figures 7 and 8. For these spectra the maximum SPL is generally found in the 1.5 kHz third-octave band.

Figure 10 shows the effect of the custom molded communication earplug on the speech spectrum. The amplification at the 800 Hz and 1000 Hz band is attributed to the resonant frequency of the hole through the earplug. In effect this hole tends to act as a high frequency filter. The insert communication earplug tends to reduce the speech energy above 1 kHz.

A comparison of the spectrum and levels generated by the Telex receiver adapted to the French insert communication earplug versus the Standard Air Force H-133 headset communication unit can be seen in figure 11. These

spectra represent the maximum speech reception level with a normal voice input to either AIC-10/18 inter-communication unit. The difference in overall SPL is 13.5 dB with the H-133 capable of producing a slightly better high frequency response.

Table V presents the dB(A) levels for the various devices with two different talking levels with maximum and minimum gain levels. Those levels in parenthesis have been calculated on the basis of 22 dB attenuation provided by the line potentiometer.

SECTION IV

ATTENUATION OF PROTECTIVE DEVICES

METHOD

The attenuation test procedure measures the shift in threshold of hearing in a free field condition induced by the ear protection device. The mean differences between these values were designated as the amount of attenuation provided by the device. The evaluation was in accordance with the American National Standards Institute's "Method for the Measurement of Real-Ear Attenuation at Threshold" (REAT) Z24.22-1957. This method of measurement used 10 normal hearing university students ranging in age from 18 years to 24 years.

Threshold of hearing data for nine discrete frequencies: 125, 250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz were obtained from the subjects in the following conditions: without device, with device. The devices evaluated included (1) H-133 communication headset, (2) French custom molded earplug (previously evaluated), (3) French communication earplug, (4) H-133 (partial foam liner) plus the French communication plug and (5) H-133 (full foam liner) plus the French communication plug.

The H-133 (partial foam liner), as seen in figure 12, was included in the evaluation because it provided more physical room inside the earcup and relieves the pressure on the earplug associated with the H-133 (full foam liner) (figure 13). The partial foam liner can be fabricated by substituting a liner from a David Clark 19A or any other David Clark deep dome earcup.

INSTRUMENTATION AND PROCEDURE

The instrumentation for measuring REAT consisted of: an audio oscillator, an electronic switch, an operators' attenuator (110 dB total range in 1 dB steps), an audio amplifier, and a 25-watt loudspeaker. The loudspeaker was

positioned 4 feet in front of the subject. The harmonic distortion was less than 3 percent over the levels and frequency range used. The subjects found their threshold of hearing by varying their attenuator until the test tone was barely audible. Each subject found his threshold three repeat times for each frequency without and with each device that was evaluated.

RESULTS

Table VI lists the mean attenuation characteristics of the items evaluated. The French communication earplug did not provide as much attenuation at any of the frequencies tested as did the solid comparable French custom earplug. The addition of the communication earplug to the H-133 earmuff provided more attenuation than the H-133 by itself with the exception of 500 Hz. The H-133 full foam liner did provide slightly more attenuation than the H-133 partial foam liner with the greatest difference (6 dB) occurring at 4 kHz.

SECTION V

MAXIMUM PERMISSIBLE EXPOSURE TIME

AMBIENT NOISE

Tables VII and VIII show the overall dB(A), dB(C) and maximum permissible exposure time in minutes per 8 hour work day to the various power settings at each position for all items evaluated in Section IV (Table VI) in this report. These permissible exposure times are in accordance with the proposed revision to AFR 160-3*, and are based on the 125 Hz to 4 kHz octave bands.

The usage of the H-133 partial foam liner in conjunction with the French communication earplug (the combination proposed for use in the flight prep area) would allow personnel to be exposed up to 8 hours continuously at the 70% and 85% engine power settings. These maximum exposure times per day decrease as the engine power settings increase, with the time limit of 36 minutes per 8 hour day at position 4, afterburner zone 5. Since the total runup through all power settings do not exceed 45 minutes, no problem can be foreseen in exceeding the criteria. In general, most of the 45 minute maintenance time is accomplished at engine power settings up to Military. The afterburner power settings are limited to a very short duration. Two to three 45-minute exposures per day at any position would not be expected to cause any permanent threshold shift if the H-133 partial foam and French communication earplugs are worn properly.

SPEECH LEVELS

Observations and discussions with the ground maintenance personnel revealed that the gain of the line potentiometer was usually set for the

*Air Force Regulation No. 160-3, Medical Service, Dept of the Air Force, Washington, D.C. (Proposed Revision, July 1971).

lower gain levels (those below 50%). Based on this and the various field and laboratory investigations accomplished, a dB(A) level for the speech signal could be estimated.

The long term average level expected is approximately 100 dB(A) with considerable off time (that time where no one communicates). Since even normal conversation includes considerable pauses, the total exposure time to the speech acoustic signal is even further reduced. Although it is difficult to equate this speech exposure to a continuous acoustic signal it is estimated that 100 dB(A) for 10 minutes, or approximately one fourth of the runup time, would approximate a continuous exposure. According to the proposed criteria of AFR 160-3 this dB(A) level would limit the continuous exposure time to 27 minutes. Based on the above, two to three 45 minute speech exposures, on the communication system in question, per day at the intensity of 100 dB(A) is possible without exceeding the proposed criteria. This level is based on an estimated noise level alone and does not consider the cumulative effect of the ambient noise exposure, and those exposures received by the personnel during interim periods. These variables could, of course, influence the proposed time limit significantly. To be absolutely assured that no significant threshold shift occurs from the combined exposures to the ambient noise and voice signal, audiograms would be obtained on all personnel involved at specified intervals.

SECTION VI

CONCLUSIONS

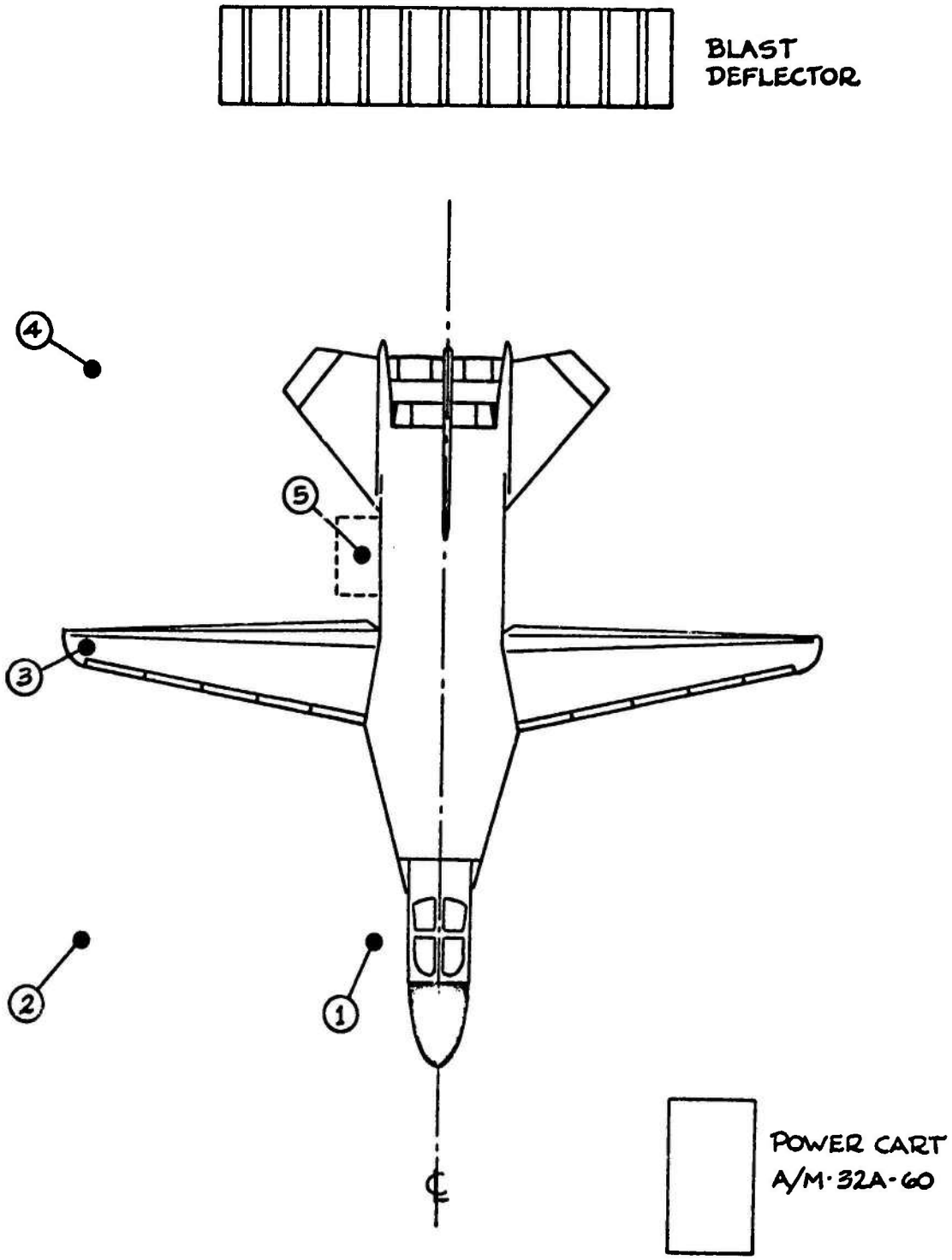
The noise generated by the F-111A in the prep area at McClellan AFB is intense enough to mask speech reception of personnel wearing standard AF H-133 communication headsets. This problem was eliminated by use of a French Custom Molded insert earplug in conjunction with the H-133. In the existing system all personnel in the communication link have an open or "hot" microphone. If only one of those persons loses the sealing characteristics of the muzzle microphone, noise is introduced into the communication system which causes considerable speech masking regardless of the device worn. To eliminate this each individual station should be provided a push-to-talk switch thereby reducing the possibility of introducing ambient noise into the communication system.

Since no significant attenuation differences were found between the attenuation characteristics of the H-133 partial foam liner and the H-133 full foam liner, it is recommended that the full foam liner of the Stock H-133 be replaced with partial liners as found in David Clark 19A over the ear protector models. These liners can be purchased directly from David Clark Company, Worcester, Mass. By incorporating the partial foam liner into the earcup dome considerably more physical room is available for the communication earplug without a significant reduction in sound protection.

The estimates of maximum permissible exposure times for both the ambient noise and speech signal are the results of optimum conditions, e.g., best possible seal on protective devices, gain levels of the communication system, etc. In an operational situation these conditions are not always met. If one person were to obtain a poor seal on the protective devices

and likewise increase the gain on the communication system, he would be subject to exceeding the criteria as presented in this report. Periodic audiograms are recommended, as specified in AFR 160-3, to be given to all personnel associated with these systems to insure no significant threshold shift occurs.

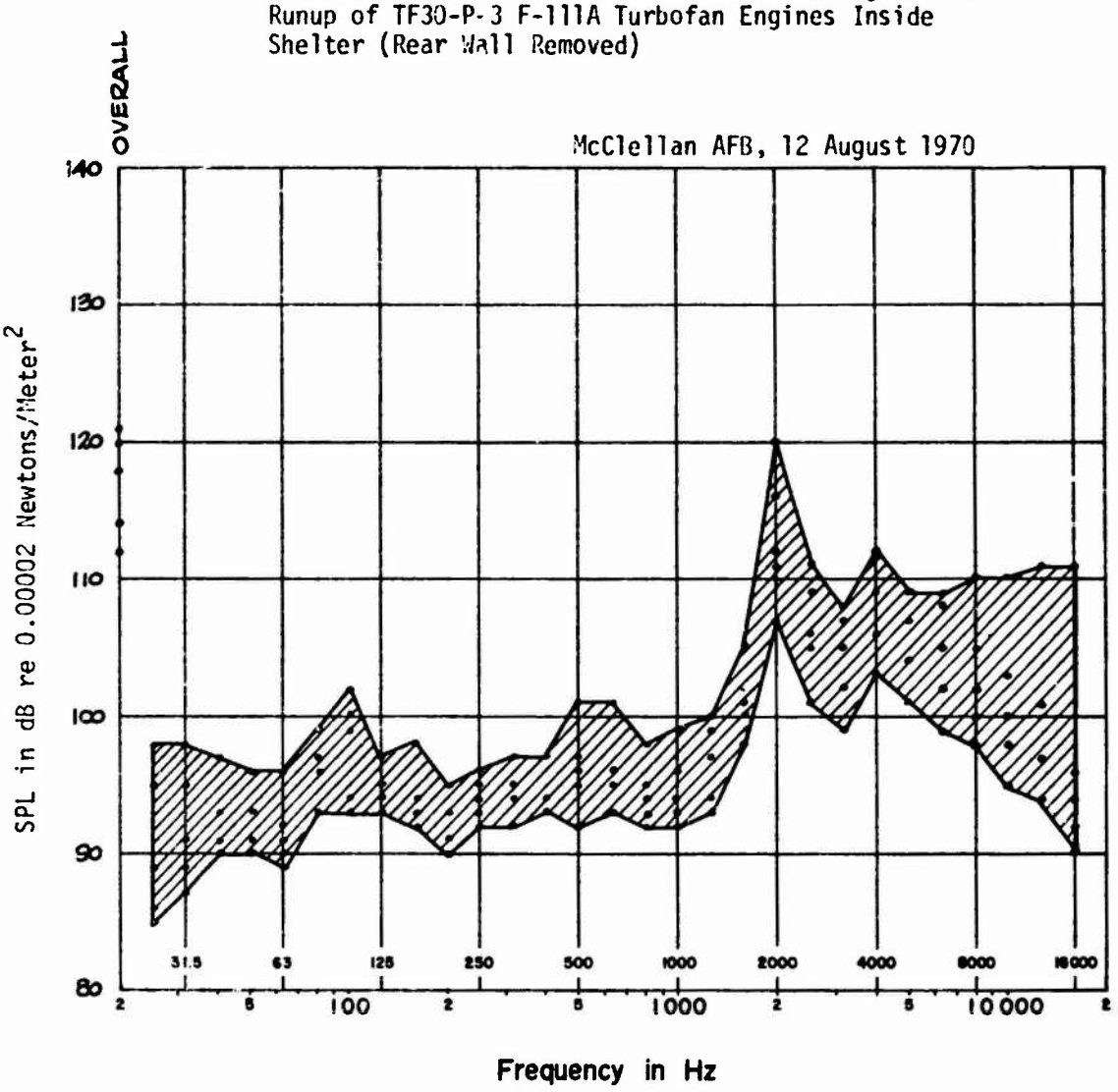
In general, the attenuation improvement of the H-133 plus the custom molded communication insert over the H-133 by itself is significant enough to increase the allowable exposure time in the F-111A noise environment, a factor of approximately four. In addition, there is a marked speech reception improvement of the combination over the either unit independently.



F·111A MEASUREMENT LOCATIONS

Figure 1

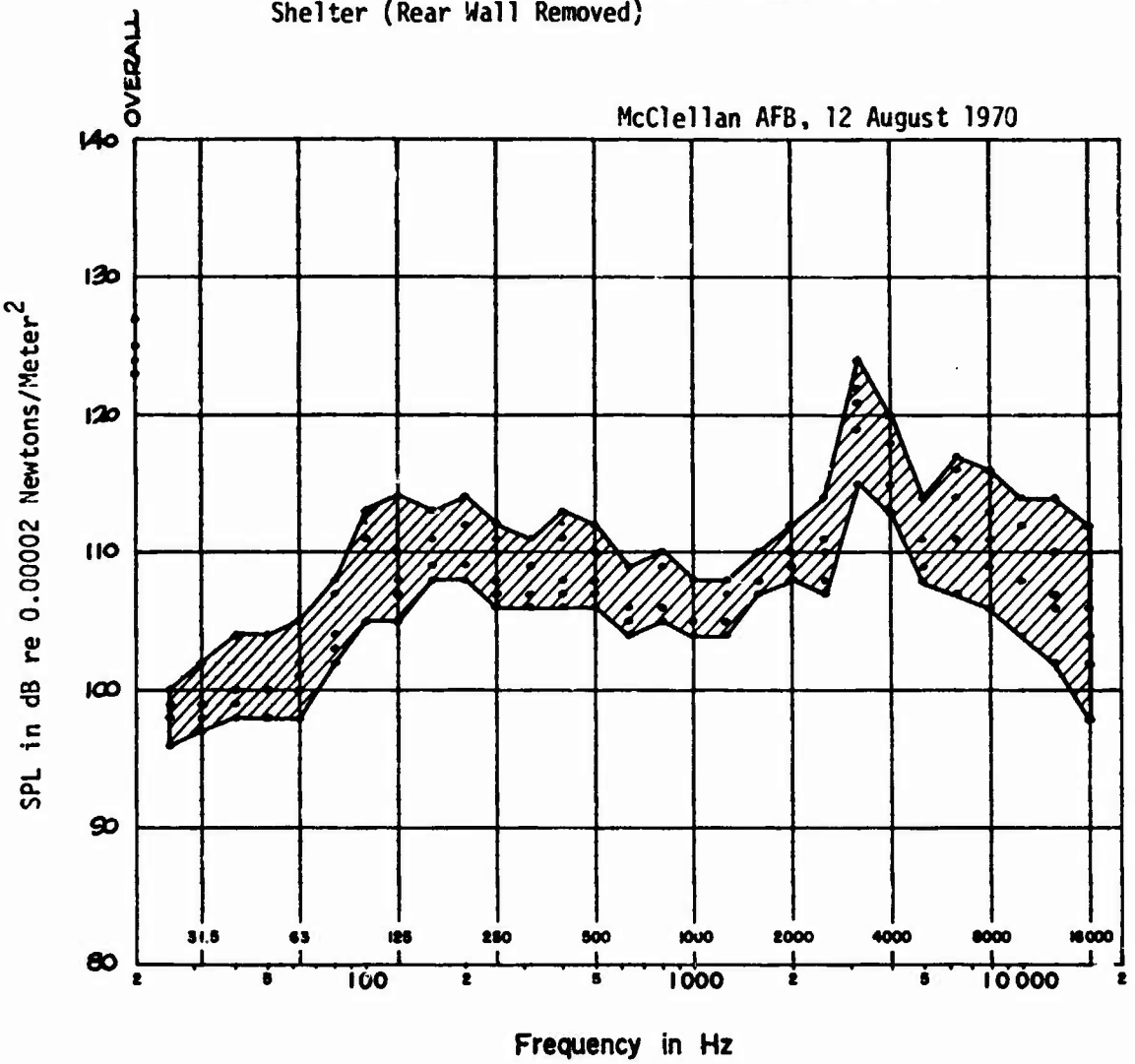
Measured SPL At Maintenance Positions During Ground Runup of TF30-P-3 F-111A Turbofan Engines Inside Shelter (Rear Wall Removed)



RIGHT ENGINE - 70%, LEFT ENGINE - IDLE

Figure 2

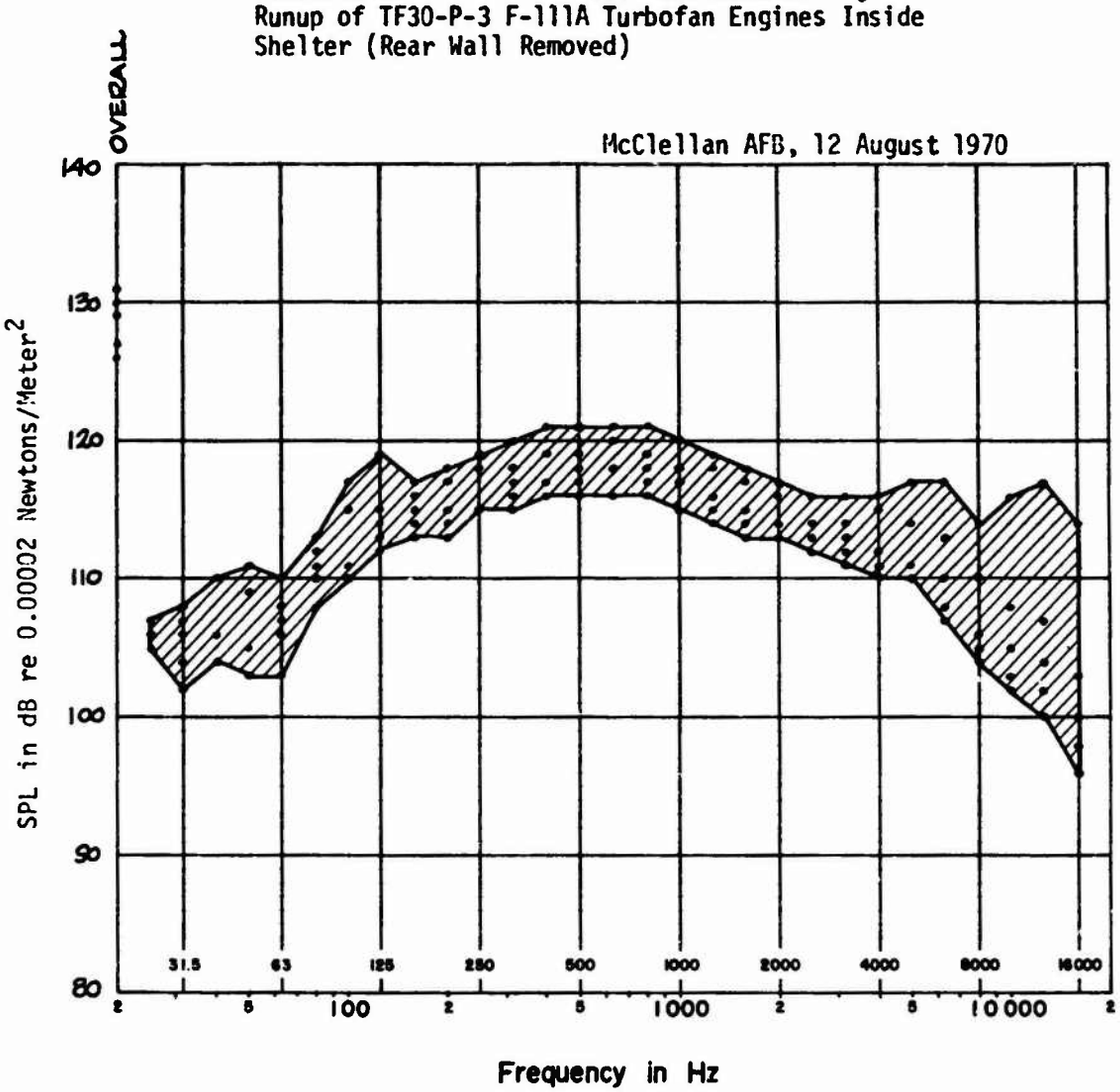
Measured SPL At Maintenance Positions During Ground Runup of TF30-P-3 F-111A Turbofan Engines Inside Shelter (Rear Wall Removed)



RIGHT ENGINE - 85%, LEFT ENGINE - IDLE

Figure 3

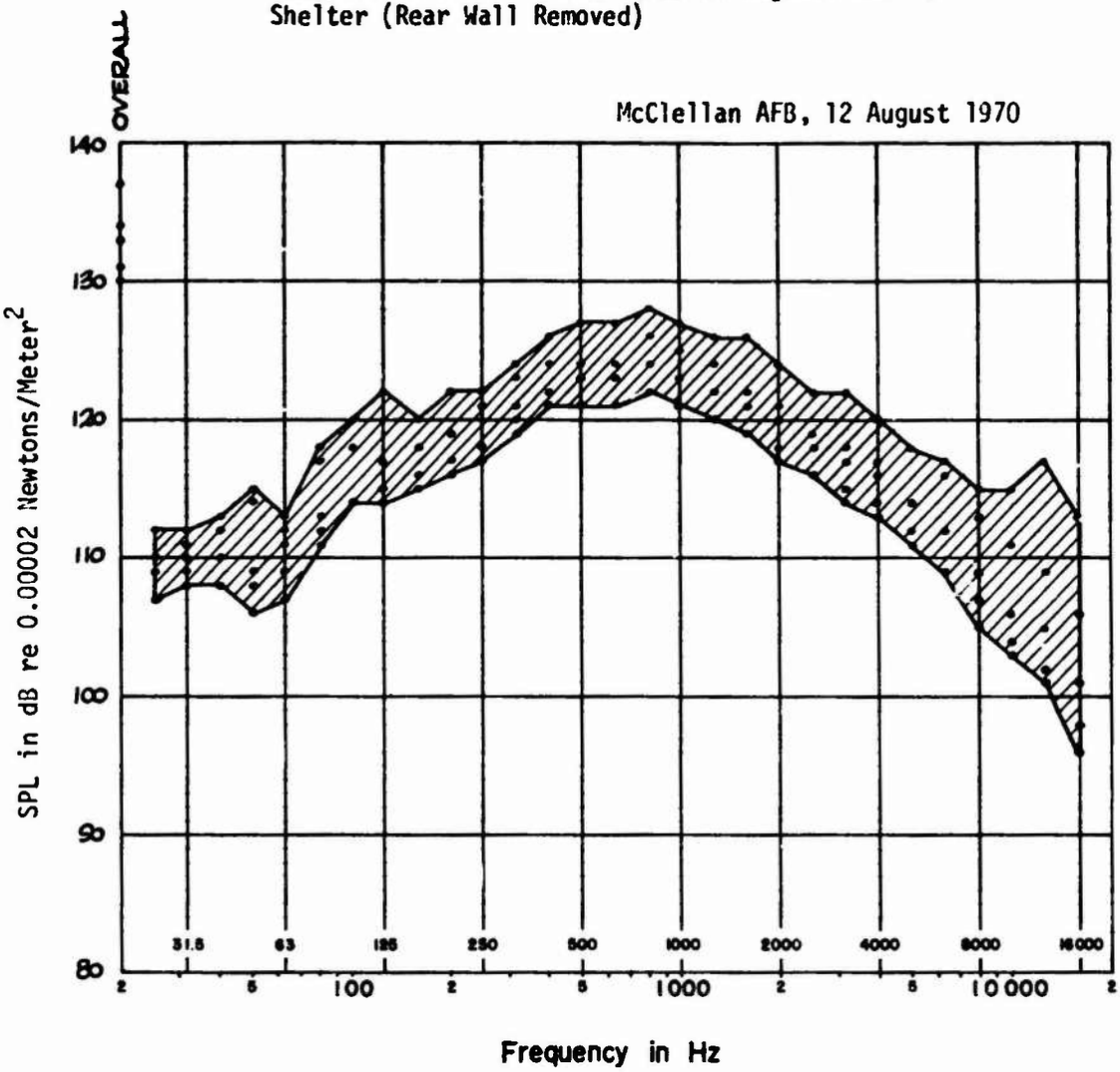
Measured SPL At Maintenance Positions During Ground Runup of TF30-P-3 F-111A Turbofan Engines Inside Shelter (Rear Wall Removed)



RIGHT ENGINE - MILITARY POWER, LEFT ENGINE - IDLE

Figure 4

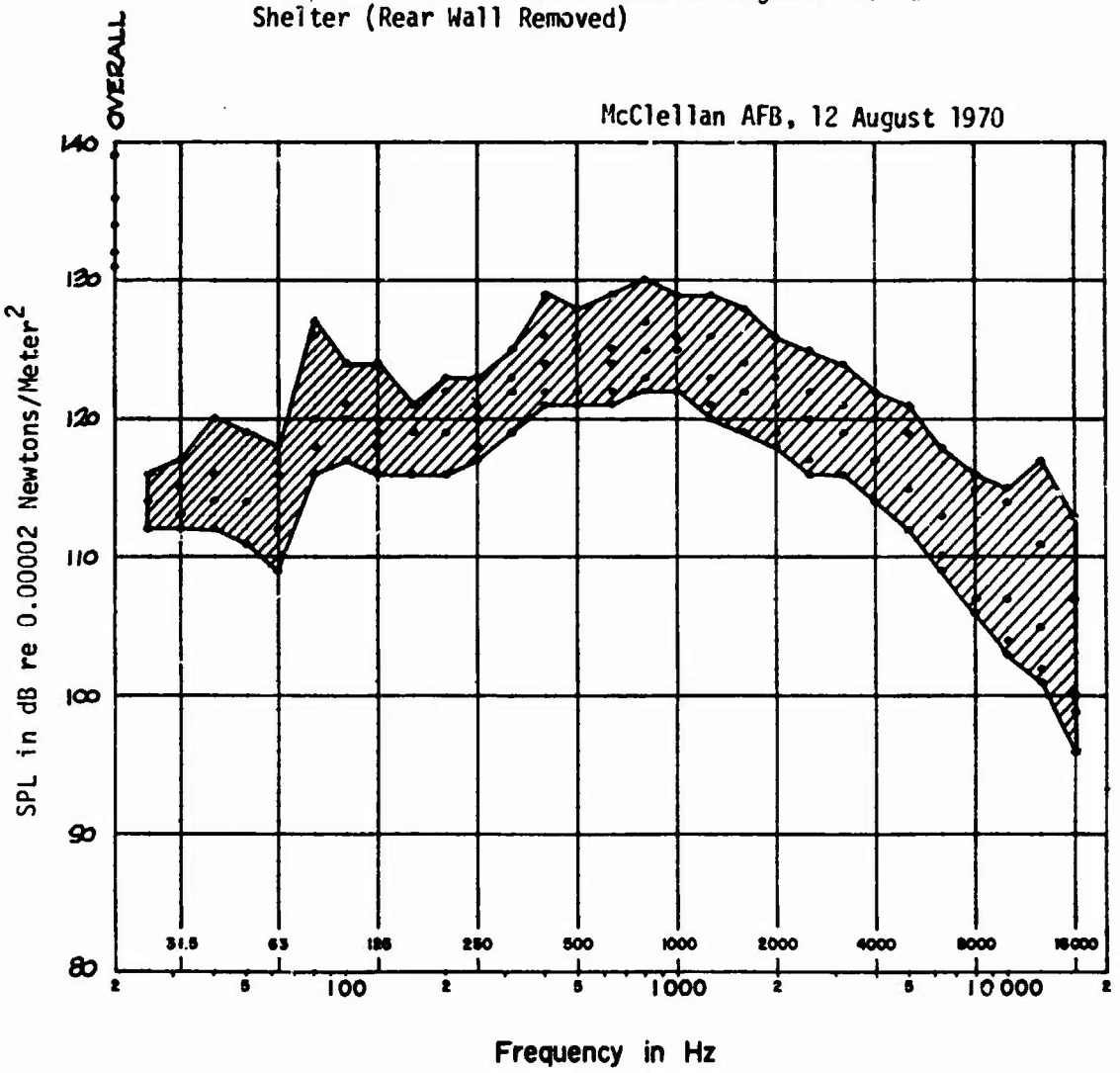
Measured SPL At Maintenance Positions During Ground Runup of TF30-P-3 F-111A Turbofan Engines Inside Shelter (Rear Wall Removed)



RIGHT ENGINE - ZONE 3 AFTERBURNER, LEFT ENGINE - IDLE

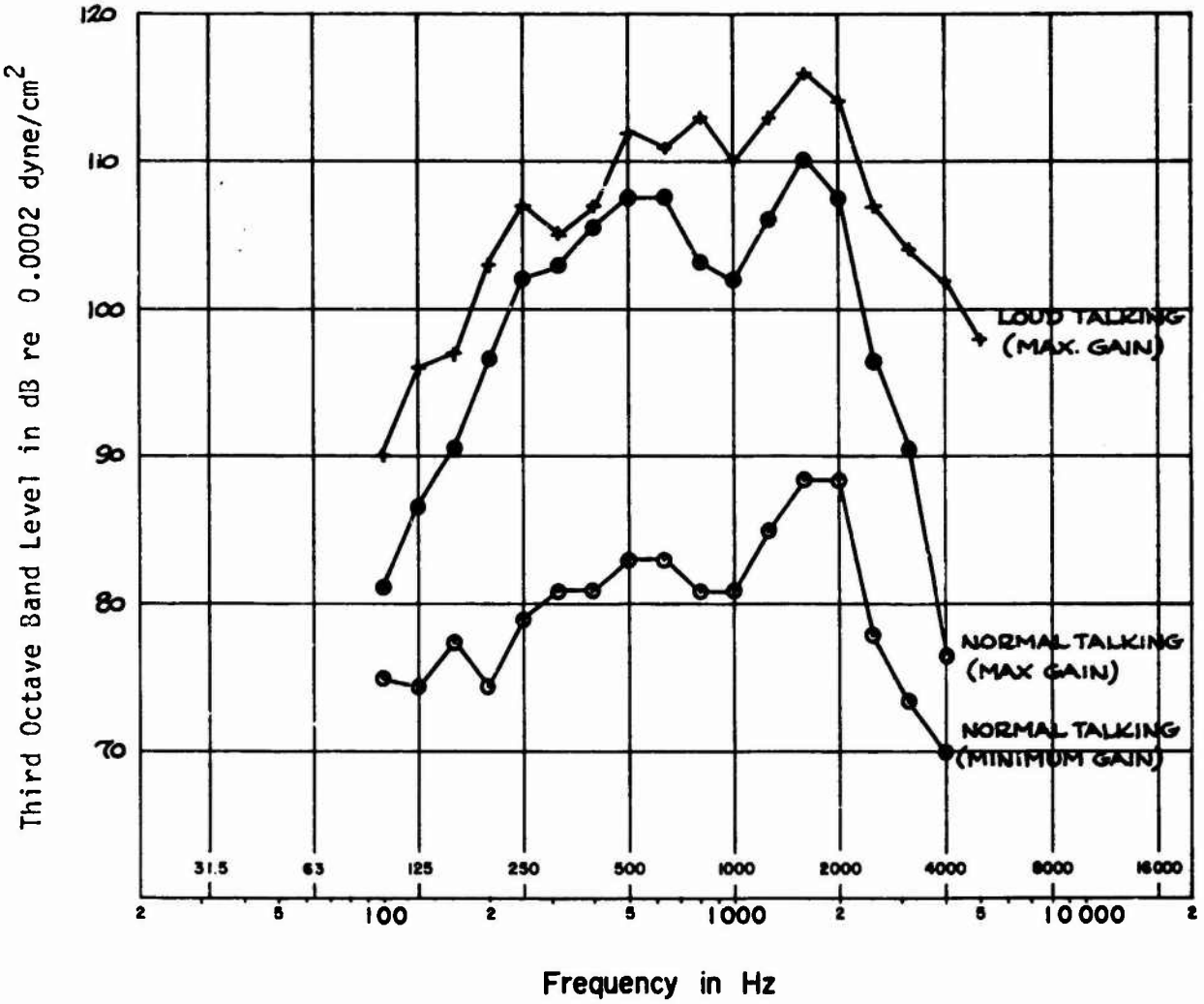
Figure 5

Measured SPL At Maintenance Positions During Ground Runup of TF30-P-3 F-111A Turbofan Engines Inside Shelter (Rear Wall Removed)



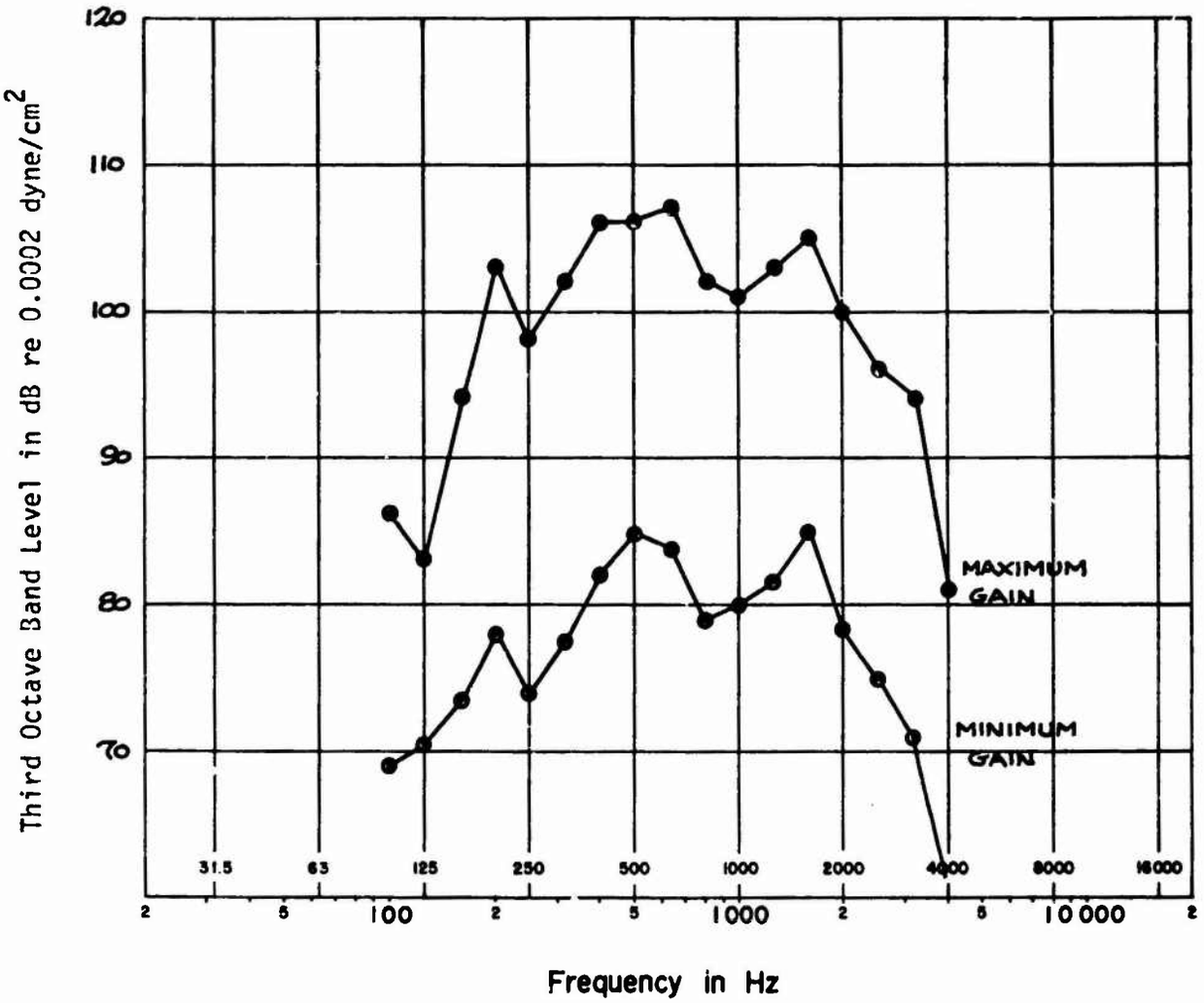
RIGHT ENGINE - ZONE 5 AFTERBURNER, LEFT ENGINE - IDLE

Figure 6



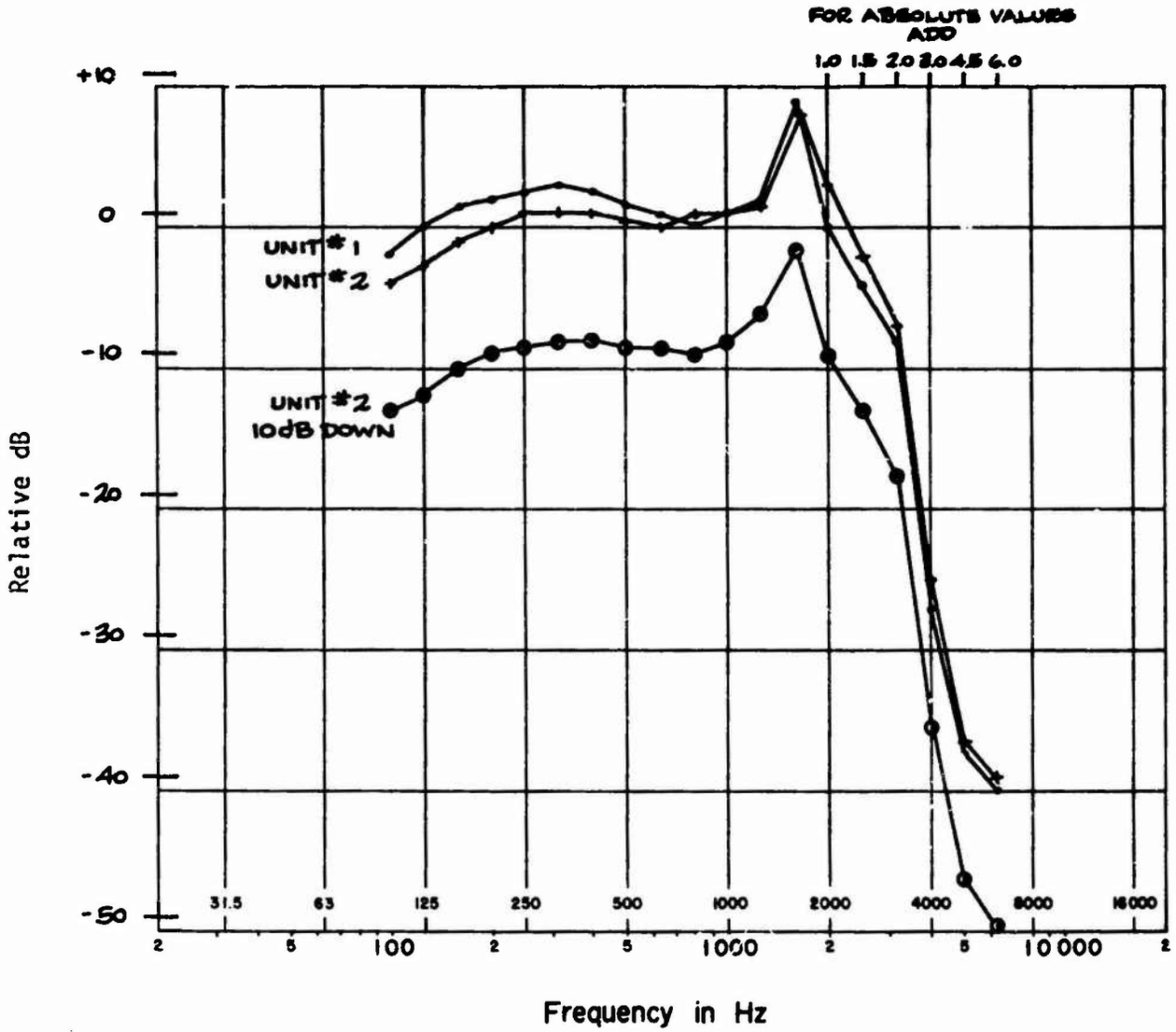
OPERATIONAL TYPE CONVERSATION RECORDED FROM
TELEX INSERT RECEIVER AT VARIOUS GAIN SETTINGS

Figure 7



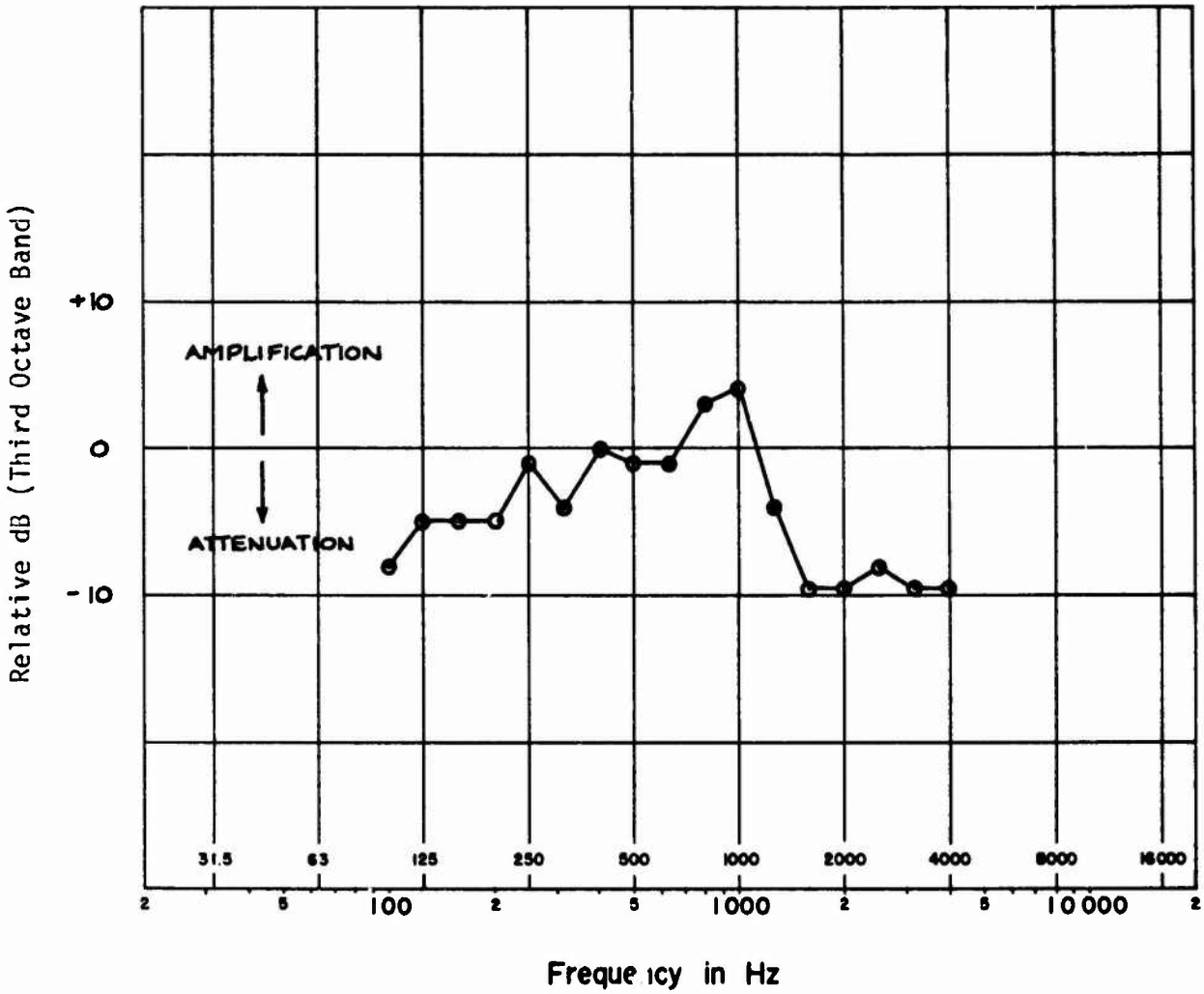
CONTROL TYPE CONVERSATION RECORDED FROM TELEX RECEIVER
AS MAXIMUM AND MINIMUM GAIN SETTINGS

Figure 8



FREQUENCY RESPONSE OF TWO TELEX, TYPE RTW-04,
500e INSERT RECEIVERS

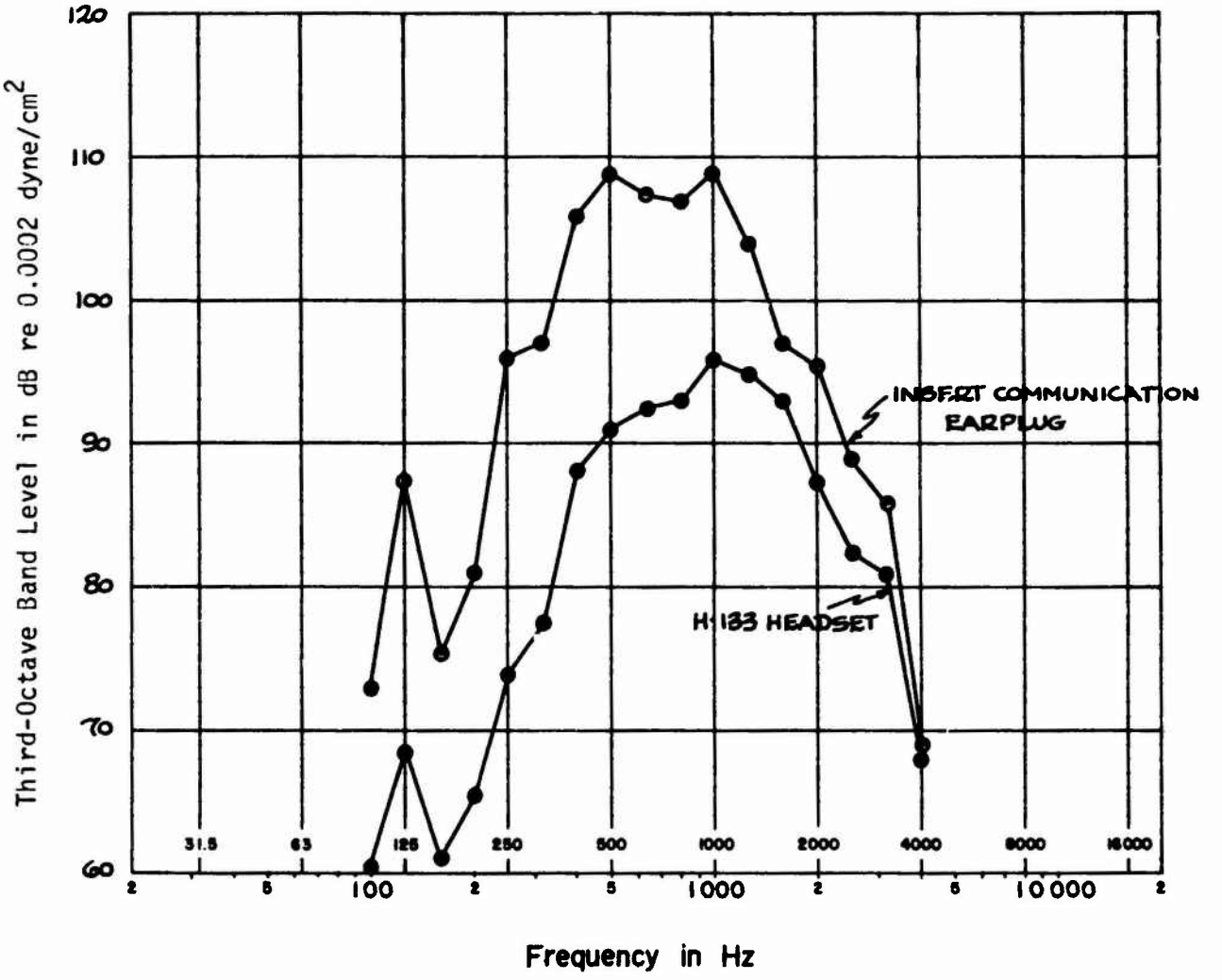
Figure 9



EFFECTS OF CUSTOM MOLDED COMMUNICATION EARPLUG ON SPEECH

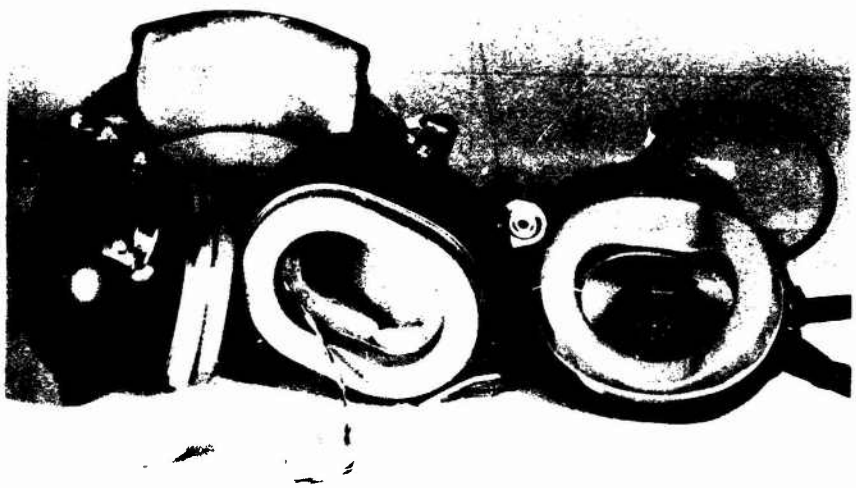
This graph represents the difference between the Telex unit directly on coupler and the Telex unit plus the custom molded earplug on coupler.

Figure 10



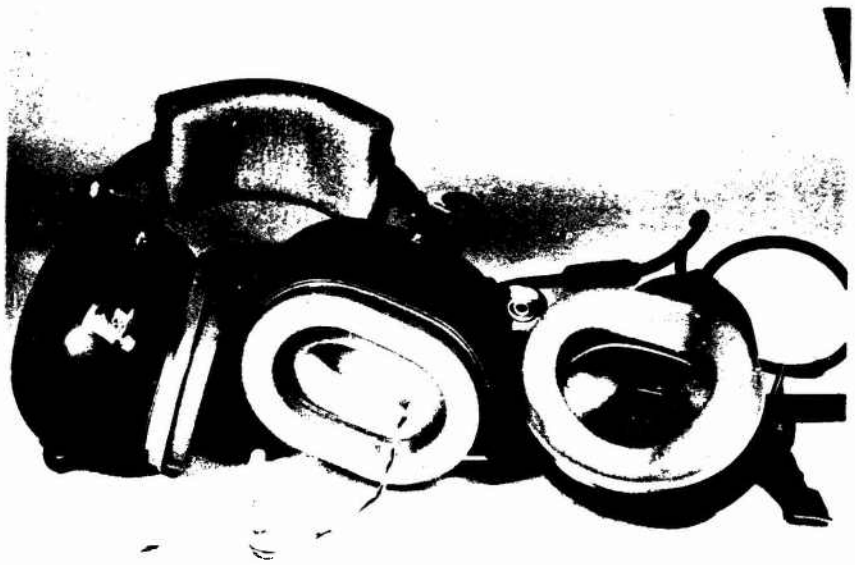
THIRD-OCTAVE BAND SOUND PRESSURE LEVEL SPECTRUMS FOR THE INSERT COMMUNICATION RECEIVER AND STANDARD AIR FORCE H-133 HEADSET. NORMAL TALKING LEVEL, MAXIMUM GAIN SETTING.

Figure 11



H-133 WITH PARTIAL FOAM LINER

Figure 12



H-133 WITH FULL FOAM LINER

Figure 13

TABLE I

F-111A - MAINTENANCE LOCATIONS INSIDE RUNUP SHELTER - REAR WALL REMOVED
ENGINE TRIM-MCCLELLAN AFB, CALIFORNIA, 12 AUG 70

TEST 70-009-001
RUN 1

SOUND PRESSURE LEVELS (DB RE .00002 N/SQ M) AT SPECIFIED LOCATION/CONDITION

BANDWIDTH = 1/3 OCTAVE

BAND CENTER FREQ (HZ)	LOCATION/CONDITION: RIGHT ENGINE - 70 PERCENT, LEFT ENGINE - IDLE					RIGHT ENGINE - 85 PERCENT, LEFT ENGINE - IDLE					RIGHT ENGINE - MILITARY, LEFT ENGINE IDLE				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
25	95	89	86	85	98	99	96	98	96	100	105	106	107	106	107
31.5	95	89	91	87	98	99	98	99	97	102	102	106	107	104	108
40	93	90	91	90	97	100	97	99	100	104	104	104	106	106	110
50	90	91	93	91	96	98	97	100	104	104	105	103	105	109	111
63	91	90	92	89	96	100	98	101	102	105	107	103	106	108	110
80	93	93	97	96	99	102	103	104	107	108	111	108	110	112	113
100	94	93	102	99	100	103	105	111	113	111	111	110	115	117	115
125	94	93	94	97	95	107	105	108	114	110	114	112	113	119	115
160	93	92	93	94	98	109	108	108	111	113	114	113	115	116	117
200	90	90	91	93	95	109	108	108	112	114	114	113	115	118	117
250	95	92	94	93	96	107	106	108	111	112	115	115	118	119	118
315	95	92	94	95	97	107	106	109	111	111	116	115	117	120	118
400	97	93	94	93	97	107	106	108	113	111	116	116	117	121	119
500	96	95	97	92	101	107	106	108	112	110	117	116	118	121	119
630	95	96	95	93	101	105	104	106	109	109	116	116	118	121	120
800	95	94	93	92	99	105	105	106	109	110	117	116	118	121	119
1000	96	94	94	92	99	105	104	105	108	108	115	115	117	120	118
1250	99	97	94	93	100	105	104	105	107	108	115	114	116	119	118
1600	105	101	99	98	104	110	108	107	108	110	114	113	115	118	117
2000	120	116	111	107	112	112	110	109	108	110	114	113	114	117	116
2500	111	109	105	101	106	114	111	108	107	110	112	112	113	116	114
3150	108	105	102	99	107	125	121	119	115	122	112	111	113	116	114
4000	112	109	106	103	109	120	118	115	113	118	111	110	112	115	116
5000	109	107	104	101	109	114	111	109	108	114	110	110	111	114	117
6300	108	105	102	99	109	117	114	111	107	116	108	107	110	113	117
8000	105	102	100	98	110	113	111	109	106	116	105	104	106	110	114
10000	103	99	98	95	110	112	108	108	104	114	103	102	105	108	116
12500	101	97	97	94	111	110	106	107	102	114	102	100	104	107	117
16000	96	92	94	90	111	106	102	104	98	112	98	96	100	103	114
OVERALL	122	119	115	112	120	128	125	124	124	128	127	127	129	132	131

TABLE II

F-111A - MAINTENANCE LOCATIONS INSIDE RUNUP SHELTER - REAR WALL REMOVED
ENGINE TRIM-MCCLELLAN AFB, CALIFORNIA, 12 AUG 70

TEST 70-009-001
RUN 2

SOUND PRESSURE LEVELS (DB RE .00002 N/SQ M) AT SPECIFIED LOCATION/CONDITION

BANDWIDTH = 1/3 OCTAVE

	LOCATION/CONDITION									
	RIGHT ENGINE - ZONE 3 AB LEFT ENGINE - IDLE					RIGHT ENGINE - ZONE 5 AB LEFT ENGINE - IDLE				
BAND CENTER FREQ (HZ)	1	2	3	4	5	1	2	3	4	5
25	107	109	110	109	112	112	112	114	114	116
31.5	108	111	110	109	112	112	115	113	113	117
40	108	110	110	112	113	112	112	114	116	120
50	108	106	109	114	115	111	111	114	119	119
63	109	107	111	112	113	112	109	116	117	118
80	112	111	113	117	118	118	116	120	127	126
100	114	114	118	120	118	120	117	121	124	124
125	115	114	117	122	117	118	116	119	124	120
160	116	115	118	118	120	116	116	119	121	121
200	117	116	119	122	122	116	116	119	123	122
250	118	117	121	122	122	118	117	120	123	121
315	120	119	121	124	123	119	119	122	125	123
400	121	121	122	126	124	122	121	124	129	126
500	121	121	123	127	124	122	121	125	128	126
630	121	121	123	127	124	122	121	124	129	125
800	122	122	124	128	126	123	122	125	130	127
1000	121	121	123	127	125	122	122	125	129	126
1250	120	120	122	126	124	121	120	123	129	126
1600	119	119	121	126	122	119	119	122	128	124
2000	118	117	120	124	121	119	118	121	126	123
2500	116	116	118	122	119	117	116	120	125	122
3150	115	114	117	122	118	116	116	119	124	121
4000	114	113	116	120	117	114	114	117	122	120
5000	112	111	114	118	118	112	112	115	121	119
6300	109	109	112	116	117	110	109	113	118	118
8000	107	105	109	113	114	107	106	110	116	115
10000	104	103	106	111	115	104	103	107	114	115
12500	102	101	105	109	117	102	101	105	111	117
16000	98	96	101	106	113	99	96	100	107	113
OVERALL	131	131	133	137	135	133	132	135	139	137

TABLE III

F-111A - MAINTENANCE LOCATIONS INSIDE RUNUP SHELTER - REAR WALL REMOVED
ENGINE TRIM-MCCLELLAN AFB, CALIFORNIA, 12 AUG 70

TEST 70-009-001
RUN 1

SOUND PRESSURE LEVELS (DB RE .00002 N/SQ M) AT SPECIFIED LOCATION/CONDITION

BANDWIDTH = OCTAVE

BAND CENTER FREQ (HZ)	LOCATION/CONDITION: RIGHT ENGINE - 70 PERCENT, LEFT ENGINE - IDLE					RIGHT ENGINE - 85 PERCENT, LEFT ENGINE - IDLE					RIGHT ENGINE - MILITARY, LEFT ENGINE IDLE				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
31.5	99	94	95	93	102	104	102	103	103	107	109	110	111	110	113
63	96	96	99	98	102	105	105	107	110	111	113	110	112	115	116
125	98	97	103	102	103	112	111	114	118	116	118	117	119	122	121
250	99	96	98	99	101	113	112	113	116	117	120	119	122	124	122
500	101	100	100	97	105	111	110	112	116	115	121	121	122	126	124
1000	102	100	98	97	104	110	109	110	113	114	121	120	122	125	123
2000	121	117	112	108	113	117	115	113	112	115	118	117	119	122	121
4000	115	112	109	106	113	126	123	121	118	124	116	115	117	120	121
8000	111	107	105	102	114	119	116	114	111	120	111	110	112	116	121
16000	102	98	99	95	114	111	107	109	107	116	103	101	105	108	119
OVERALL	122	119	115	112	120	128	125	124	124	128	127	127	129	132	131

TABLE IV

TEST 70-009-001
RUN 2

F-111A - MAINTENANCE LOCATIONS INSIDE RUNUP SHELTER - REAR WALL REMOVED
ENGINE IRIM-MCCLELLAN AFB, CALIFORNIA, 12 AUG 70

SOUND PRESSURE LEVELS (DB RE .00002 N/SQ M) AT SPECIFIED LOCATION/CONDITION

BANDWIDTH = OCTAVE

BAND CENTER FREQ (HZ)	LOCATION/CONDITION: RIGHT ENGINE - ZONE 3 AB, LEFT ENGINE - IDLE					RIGHT ENGINE - ZONE 5 AB, LEFT ENGINE - IDLE				
	1	2	3	4	5	1	2	3	4	5
31.5	112	115	115	115	117	117	118	118	119	123
63	115	113	116	120	121	120	118	122	128	127
125	120	119	122	125	123	123	121	125	128	127
250	123	122	125	128	127	123	122	125	129	127
500	126	126	127	131	129	127	126	129	133	130
1000	126	126	128	132	131	127	126	129	134	131
2000	123	122	125	129	125	123	123	126	131	128
4000	119	118	121	125	122	119	119	122	127	125
8000	112	111	114	119	120	112	111	115	121	121
16000	103	102	106	111	118	104	102	106	112	118
OVERALL	131	131	133	137	135	133	132	135	139	137

TABLE V

OVERALL (A) WEIGHTED SPEECH SOUND LEVEL EXPRESSED IN dB (A) FOR THE VARIOUS DEVICES AT TWO DIFFERENT TALKING LEVELS WITH MAXIMUM AND MINIMUM GAIN SETTINGS

	Loud Voice		Normal Voice	
	Max Gain	Min Gain	Max Gain	Min Gain
Telex Receiver	123	(101)	117	95
Insert Earplug	(119)	(97)	113	(91)
H-133 Headset	(107)	(85)	101	(79)

Note: Items in parenthesis ( ) are calculated.

TABLE VI

ATTENUATION OF DEVICES TESTED IN dB

Frequency (Hz)	H-133 Communication Earmuff (Full Foam)	Custom Molded Earplug	Communication Custom Molded Earplug	H-133 (Partial Foam) Plus Communication Earplug	H-133 (Full Foam) Plus Communication Earplug
125	20	21	12	27	29
250	29	23	10	33	34
500	42	26	13	37	38
1K	30	31	19	40	41
2K	34	35	27	46	47
3K	30	42	40	52	52
4K	38	38	34	49	55
6K	36	39	26	41	45
8K	37	34	23	42	41

*U.S.Government Printing Office: 1972 — 759-086/656

TABLE VII

AEROSPACE MEDICAL RESEARCH LABORATORY (MRRE), WRIGHT-PATTERSON AFB, OHIO

F-111A NOISE ENVIRONMENTS - MAINTENANCE LOCATIONS INSIDE RUNUP SHELTER - REAR WALL REMOVED — TEST NUMBER 70-069-001
ENGINE TRIM-MCCLELLAN AFB, CALIFORNIA, 12 AUG 70

MEASURES OF HUMAN NOISE EXPOSURE* WITH AND WITHOUT EAR PROTECTION AT SPECIFIED LOCATION/CONDITION
A-WEIGHTED OVERALL SOUND LEVEL (OASL(A) IN DB(A) RE .00002 N/SQ M) RECEIVED BY EAR **
C-WEIGHTED OVERALL SOUND LEVEL (OASL(C) IN DB(C) RE .00002 N/SQ M) RECEIVED BY EAR **
MAXIMUM PERMISSIBLE EXPOSURE TIME (T IN MINUTES) PER 8 HOUR WORK DAY

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	LOCATION/CONDITION														
	RIGHT ENGINE - 70 PERCENT LEFT ENGINE - IDLE					RIGHT ENGINE - 85 PERCENT LEFT ENGINE - IDLE					RIGHT ENGINE - MILITARY LEFT ENGINE IDLE				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
WITH NO PROTECTION															
OASL(A)	123	119	115	112	118	128	125	123	122	126	125	124	126	129	128
OASL(C)	121	118	114	111	117	127	124	123	124	126	127	126	128	131	130
T	3	4	6	7	4	2	3	3	3	2	3	2	2	2	2
H-133 EAR MUFF															
OASL(A)	87	86	82	79	84	97	93	92	90	95	93	92	94	97	95
OASL(C)	83	85	86	84	86	97	95	96	99	98	99	98	101	104	102
T	374	343	480	480	480	41	79	94	140	56	79	94	66	41	56
CUSTOM MOLDED EARPLUG															
OASL(A)	87	84	80	77	82	90	88	88	91	91	95	95	97	100	98
OASL(C)	87	84	84	82	86	95	94	96	99	99	102	101	103	106	104
T	281	480	480	480	480	140	219	219	114	114	56	56	41	27	36
COMMUNICATION EARPLUG															
OASL(A)	96	92	88	87	93	100	98	100	103	103	108	107	109	112	111
OASL(C)	96	93	94	93	97	106	105	107	110	110	113	113	115	117	116
T	48	94	174	280	79	27	36	27	19	19	11	12	10	7	8
H-133 (PARTIAL FOAM) PLUS COMMUNICATION EARPLUG															
OASL(A)	77	73	70	67	73	80	78	79	81	82	86	85	87	90	89
OASL(C)	77	75	78	76	78	86	86	89	92	91	93	92	95	98	96
T	480	480	480	480	480	480	480	480	480	480	363	480	280	140	174
H-133 (FULL FOAM) PLUS COMMUNICATION EARPLUG															
OASL(A)	75	72	69	66	71	79	77	77	80	80	85	84	86	89	87
OASL(C)	76	73	76	75	76	85	84	87	90	89	92	91	93	96	94
T	480	480	480	480	480	480	480	480	480	480	480	480	363	174	280

* IN ACCORDANCE WITH PROPOSED REVISION (1970) TO AFR 160-3.
** FOR THE FREQUENCY RANGE COVERED BY THE 125 HZ -- 4K HZ OCTAVE BANDS

TABLE VIII

AEROSPACE MEDICAL RESEARCH LABORATORY (AFSC), WRIGHT-PATTERSON AFB, OHIO

TEST NUMBER 70-669-JJ1

F-111A NOISE ENVIRONMENTS - MAINTENANCE LOCATIONS INSIDE RUNUP SHELTER - REAR WALL REMOVED
ENGINE TRIM-VANDENBERG AFB, CALIFORNIA, 12 AUG 70

MEASURES OF HUMAN NOISE EXPOSURE* WITH AND WITHOUT EAR PROTECTION AT SPECIFIED LOCATION/CONDITION
A-WEIGHTED OVERALL SOUND LEVEL (OASL(A) IN DB(A) RE .00002 N/SQ M) RECEIVED BY EAR **
C-WEIGHTED OVERALL SOUND LEVEL (OASL(C) IN DB(C) RE .00002 N/SQ M) RECEIVED BY EAR **
MAXIMUM PERMISSIBLE EXPOSURE TIME (T IN MINUTES) PER 8 HOUR WORK DAY

	LOCATION/CONDITION									
	RIGHT ENGINE - ZONE 3 AB LEFT ENGINE - IDLE					RIGHT ENGINE - ZONE 5 AB LEFT ENGINE - IDLE				
	1	2	3	4	5	1	2	3	4	5
WITHOUT PROTECTION										
OASL(A)	130	129	132	136	133	130	130	133	138	135
OASL(C)	131	131	133	137	135	132	131	134	139	136
T	2	2	2	***	2	2	2	2	***	1
H-133 EAR MUFF										
OASL(A)	97	97	99	102	101	98	98	101	106	103
OASL(C)	102	102	105	108	106	105	103	107	110	109
T	41	41	31	15	24	36	36	24	13	19
CUSTOM MOLDED EARPLUG										
OASL(A)	100	100	102	106	103	101	100	103	108	105
OASL(C)	105	104	107	110	108	106	105	108	112	110
T	27	27	21	13	19	24	27	19	11	15
COMMUNICATION EARPLUG										
OASL(A)	112	112	114	118	116	113	112	116	120	117
OASL(C)	117	117	119	122	121	118	117	120	124	122
T	7	7	6	4	5	7	7	5	4	5
H-133 (PARTIAL FOAM) PLUS COMMUNICATION EARPLUG										
OASL(A)	90	90	92	96	94	91	90	93	98	95
OASL(C)	96	96	99	102	100	99	97	100	104	102
T	140	140	94	48	66	114	140	79	36	56
H-133 (FULL FOAM) PLUS COMMUNICATION EARPLUG										
OASL(A)	89	89	91	95	93	90	89	92	97	94
OASL(C)	95	94	97	100	98	97	95	99	103	101
T	174	174	114	56	79	140	174	94	41	66

* IN ACCORDANCE WITH PROPOSED REVISION (1970) TO AFR 160-3.
** FOR THE FREQUENCY RANGE COVERED BY THE 125 HZ - 4K HZ OCTAVE BANDS
*** ADDITIONAL EAR PROTECTION REQUIRED.

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